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DEVELOPMENT OF BUILDING TECHNIQUES
IN ISRAEL

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DEVELOPMENT OF BUILDING TECHNIQUES IN ISRAEL

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1. Scope of Building Activities.

Since the establishment of the State in 1948, the population of the country has increased from 750,000 to 2,200,000 as a result of mass immigration and natural growth. In order to meet the housing needs created by such a rapid growth, 437,000 dwelling units have been erected during this period, of which 57,000 are temporary in character, while 380,000 are permanent housing. Out of the total of permanent housing, some 127,000 dwelling units have been built by private enterprise, whereas the remaining 310,000 either directly by the Government, or through Government sponsored housing schemes.

Concurrently, this activity of housing construction has been accompanied by the erection of public buildings and a considerable number of industrial structures in the existing towns as well as in the new towns which have been built since the establishment of the State in various regions of the country.

In 1961, total investment in building activities of all kinds amounted to IL 651,600,000 of which IL 391,400,000 in housing and IL 260,200,000 in other branches of building (industrial, farm, public and commercial buildings). These investments accounted for about 30% of overall investment in the national economy in that year. Building, then, constitutes one of the most important factors in the economy.

2. Methods used in Israel's Housing Schemes.

The problems involved in the planning and execution of the country's housing schemes have been far from simple. First of all, there was the need for rapid execution in order to cope with the urgent housing needs of the rapidly growing immigration and that, within the scope of a limited budget. Furthermore, in the early period of the State's existence, mass immigration which doubled the population in the space of three years coincided with an acute shortage of both skilled labour and building materials. In order to obtain maximum output, several building schemes had to be carried out simultaneously, while plans had to be adapted to specific conditions in the various regions of the country. However, the experience gained in the execution of large-scale housing schemes made it possible to examine and compare the various systems, from the point of view of efficiency and economy.

Prevailing conditions were most difficult when the State's first housing schemes were being put into effect. The situation improved however during the second stage of the country's housing project construction, when a marked rise occurred in the quality of the structures.

During the initial stage (1949-1953), three main methods were used:

1. Building with hollow concrete blocks.
2. Concrete casting in standard form.
3. Various light types of structures.

The blocks were usually prepared on the site, and their quality was not always in accordance with the standard requirements. This fact, combined with the shortage of skilled labour, led to the development of the second method - concrete casting of walls in standard moulds. By introducing various technical innovations into the processes of mould construction and casting, this method did effect a marked saving of skilled labour. The standard forms were made of wood or plywood, the concrete was "ordinary" or "no fine".

Urgent housing needs for incoming immigrants, necessitating hasty execution, also led to the erection of temporary wooden structures, although technical considerations as well as the high percentage of imported materials involved, clearly demonstrated the disadvantages of this method. Some of these structures were assembled locally, while others were imported as complete units. Their walls were lined on the outside with wooden boards, covered inside by hard-boards, the roofs being covered by concrete tiles or asbestos.

The situation has considerably changed during the second stage of housing operations (1953-1962). Now it became possible to select construction methods more carefully, with a view to their technical implications as well as to economic considerations. Thus, the use of methods which required large quantities of imported materials was restricted to a minimum. The percentage of wooden structures dropped noticeably. The use of cast concrete walls which had been formally prevalent all over Israel, became restricted to a few areas. These measures led to a considerable saving in imported building materials - particularly in wood and iron.

Hollow concrete blocks - the quality of which was improved, as factory-made pressurised blocks replaced the former practice of primitive casting on the site - became the most important element in construction. With the development of the local building materials industry, silicate and ytong blocks were introduced. In mountainous areas, some housing projects were built of rubble stone.

3. Economic Comparison of Walls built of Various Materials.

The diagram in Fig.1 gives an economic comparison between walls constructed under various systems. The cost of walls per m^2 is given in relation to the concrete hollow-block wall as a base unit (base cost = 100). It includes the cost of concrete lintels with the required reinforcement, as well as the expenditure on plastering, where this is necessary according to the system. The diagram also shows the respective percentages of expenditure on labour on site, as well as for local and imported materials, for the various types of walls.

As the diagram shows, the cost per m^2 is lowest in the wall built of hollow concrete blocks. This explains the widespread use of this type of wall in housing projects in comparison to other systems. Thus, brick masonry walls are not constructed in public housing projects, as a result of their cost being considerably higher than the cost of concrete hollow-block walls. Similarly, the relatively high cost of rubble stone walls, which were common use in certain regions (e.g. the Jerusalem region), owing to architectural considerations, has resulted in their replacement by walls constructed of prefabricated elements with different coverings, e.g. exposed aggregate, etc.

4. The Development of Systems using Prefabricated Elements.

During the last years considerable progress has been achieved in the use of precast reinforced concrete units in the construction of new housing. This method offers the advantages of rapid execution, a saving in the quantities of materials owing to

the use of higher-quality materials, as well as a reduction in the amount of skilled labour required and economy in the use of imported materials.

The Housing Division directed its efforts, in the first place, to the introduction of all these components through the use of which, savings in foreign currency expenditure are attained. These included floors and roofs, which under more conventional systems of building required substantial amounts of wood and steel. Furthermore, the Division encouraged the development of various methods of producing prefabricated concrete trusses; notable achievements were attained in this direction. Thus, the use of wooden trusses has been almost wholly discontinued in public housing projects, where reinforced precast trusses are currently used in their place.

5. Prefabricated Systems using Medium and Large Elements.

At the present moment, three local plants are engaged in the manufacture of prefabricated building elements e.g. walls, floors of medium size. In addition, a system using large elements, in the form of cell units (cubes) of ceilings and walls has been introduced since last year.

One plant, situated at Eilat, is manufacturing 300 - 500 dwelling units per annum. The structure used under this system is composed of prefabricated elements of medium size, for floors and walls; the walls are constructed of two layers of prefabricated plates, with an air-space in between. The plates are 80 cm. in width and approximately 2.50 m. in height. Another plant, at Shderot, manufactures about 500 dwelling units per annum. The elements produced are 2.00 m x 2.50 m. in size. Floors and walls are of hollow structure with round cavities. The "Rastrum" factory, situated at Holon, manufactures about 300 dwelling units a year. The elements of the building are 1.00 m. x 2.50 m. in size and they are cast according to the "sandwich system", with a layer of light concrete alternating between two concrete layers. In Jerusalem, the erection of a first series of about 100 dwellings according to a system developed by the contractor M^r. Diskin, is nearing completion. Under this system, the elements are prepared in the form of cells of reinforced concrete cast in situ, and assembled with the aid of cranes.

6. The Contribution of Research to Development of Building Methods.

Activities in the field of building research undertaken by the Building Research Station, Israel Institute of Technology, and other institutions (the Productivity Institute, the Israeli Standard Institute, Soil Mechanics Laboratory, and the Technion's Structural Division) have considerably contributed to the development of Israel's building methods. Thanks to these research activities, important improvements have been introduced in conventional building methods, on the one hand, while at the same time the development of new building methods has largely benefited from the results of research work. The following examples may be quoted:

a. Flat Plate Floors.

The Division of Structural Engineering, Israel Institute of Technology, headed by Prof. D. Yitzhaki, has carried out a study on reinforced concrete flat plate floors(*)

This research has contributed to the solution of certain problems of resistance to punching for this type of roofs and floors. Shear reinforcement was found to be highly effective in preventing punching failure; thus it was de-

* Experimental Investigation of Flat Plate Floors, by Israel Rosenthal.
Journal of the American Concrete Institute, August 1959.

monstrated that thin, resistant slabs can be designed, with the use of round-bar reinforcement. The results of the study have made possible a wider application of this method in housing schemes, resulting in an appreciable economy in construction costs, as well as a higher speed of execution.

b. Poststressed Concrete Hollow-Block Walls.

Another study covering problems of poststressed walls, has contributed to the development of a method aimed at strengthening buildings constructed of hollow concrete blocks and built on heavy clay. According to this method, steel wire ties of ultimate strength 17,000 kg/cm² are used as a means of preventing cracking. The method is also suitable for repairing cracked buildings, and is cheaper than other methods practiced hitherto.

c. Precast Reinforced Concrete Roof Trusses for Public Housing Schemes*

As mentioned in Chapter 4, extensive development of prefabricated building methods has taken place in Israel with the active encouragement of the Ministry of Housing.

The above research has contributed to this development by determining the most suitable methods in production of R.C. trusses from the technical and economic points of view. The main conclusions arrived at were as follows: 1) "Closed" Trusses (i.e. with a horizontal tie-bar) have certain advantages over structures with separate anchor bars. 2) From the viewpoint of resistance to corrosion, all-concrete structures are preferable. 3) The average safety factor of the assembled structure, related to the ultimate load was 3.5. 4) The R.C. precast is 9% cheaper than the wooden one. 5) Foreign currency expenditure is 40% lower for the precast structure.

d. Cost Research.

Research work on building costs in Israel has contributed considerably towards a better evaluation of efficient systems, thereby achieving reductions in building costs. As an example, we shall quote the results of a research project** which was carried out last year, on the subject of rational structure of light industry buildings. Such buildings, destined for light industry and workshops, have been constructed in Israel in various systems. From the point of view of wall material - either built of concrete hollow blocks, built between columns, either cast in situ or prefabricated, or concrete walls comprising precast concrete plates assembled between precast concrete columns. From the point of view of roof construction too, various systems are practiced, those in common use being the following roofs of corrugated asbestos sheets on either steel or precast concrete elements, r.c. hyperboloid-paraboloid structures etc.

As demonstrated by the diagram in Fig. 2, this research has established the advantage of prefabricated structures, in comparison with other types of structures, from the point of view of expenditure in both local and foreign currency. Further, the economy in building costs is higher in proportion to the percentage of precast concrete elements in the structure.

Among structures with concrete roofs, there are certain advantages to hyperboloid - paraboloid shell structures, from the point of view of very low percentages of expenditure on steel and forms. It is assumed that by wider use of this

* Research Paper No. 5 by A. Alweyl, J. Fichman, J. Karni. Building Research Station, Technion, Israel Institute of Technology, Haifa 1957.

** A. Alweyl, J. Sokal, Study on Structural Systems of Industrial Structures, Building Research Station, June 1962.

system, which is characterized by simpler shuttering, in comparison with that of the cylindrical shell, lower building costs may be obtained.

7. Topical Building Problems and New Fields of Development.

The improvements hitherto registered in building methods currently employed in Israel, will undoubtedly serve as a basis for further progress in the development of technically and economically sound methods.

Two main tendencies are clearly visible in this development: 1) The introduction of methods enabling savings in skilled labour as well as increasing the speed of execution. 2) Fuller exploitation of local raw materials in the building materials industry.

The problem of manpower shortage in the country's building activity constitutes one of the main motives in the drive towards new building methods. In 1961, the scope of building activity was 33% larger than that of 1959, whereas the number of workers employed increased by a mere 7%. As in other countries with a growing industry, workers are attracted by jobs in industrial plants, where conditions are considerably more comfortable than those prevailing in out-of-doors construction jobs. Several proposals have been made with a view to solve this problem, such as: intensifying activities of professional training, grants and higher wages to building workers, etc. Albeit, among builders, the conviction that conventional building methods should be at least partially replaced by new ways of construction, if the current problems are to be solved, steadily gains ground.

Two main approaches are discernable: a) one approach is based on the concept of prefabrication of big building elements in factories, and their assembly on situ. b) a second approach favours the introduction of more efficient methods of execution on situ by means of improved organizational methods of work, as well as by a higher rate of utilization of equipment and various mechanical tools.

As is well known in many countries - and in European countries in particular - opinions vary concerning the best approach to be taken; in Israel, current tendencies favour the application of both attitudes simultaneously.

As has been previously stated, several small plants in Israel are employed in the manufacture of small or medium prefabricated elements, which have met with a certain amount of success, and are improving from year to year. Furthermore, it is proposed to build in the country, several plants for the manufacture of larger elements (room-size), similar to those existing in certain west European countries. According to this proposal, 3 to 4 such plants will be erected, in order that the overall production of prefabricated elements will attain 4,000 - 5,000 dwelling units per year, i.e. about 15% of the total number of dwellings in public housing construction. Currently, the whole matter is under consideration, mainly from its technical and economical points of view.

It is assumed that the erection of these plants will considerably ease the pressure of manpower shortage in construction works; still it is clear that other means too, will be required in order to solve the problems which currently confront us. It is beyond dispute, though, that we have to do our utmost in order to encourage the utilization of mechanical equipment, which should be, however, rationally integrated with the work organization and the various sites.

The following types of work are most suitable for more intensified and wider use of equipments: a) production of concrete on site, b) vertical and horizontal transportation on the building site, c) standard forms and scaffolding, d) cutting and bending of iron rods.

In the production of concrete on situ, a certain improvement has already been attained, as central production stations are gradually replacing production at the side of individual buildings. This system of concrete production, though, has to be further developed to the maximum possible extent. Mechanical scrapers, too, have already proved their advantage, by eliminating the most strenuous work of loading aggregates onto transportation vehicles and into the feeder element. By further increasing the use of these scrapers, a large reduction in expenditure on concrete production will be possible.

Among items of equipment which have been put into use on numerous building sites in the country, mention should be particularly made of the cranes. Both experience and research work which has been carried out in Israel, have proved that high rates of efficiency may be attained through the use of this equipment, on condition that the work is properly organized, and that due consideration is given to other factors which influence the profitability of its use. On the other hand, the high amount of investment capital required for equipment of this sort necessitates considerable care regarding the method of its operation, lest it should turn into a mere burden, where efficient work organization is lacking.

Following the considerable success with which moulds and scaffolding manufactured as standard equipment by workshops have met, there is a tendency to expand their use. It has been proved, that through the use of such standard forms and scaffolding, a lot of work is saved in assembly and dismantling, especially regarding skilled labour, also the same equipment may be used over and over for many times.

The profitability of operating electrical equipment sets in the cutting and bending of steel rods, is dependent to a large amount on the quantity of reinforcement concentrated on each individual site, as well as on the scope of the yearly production. On this subject, too, a research work has been carried out, enabling an evaluation to be made in each individual case.

After having outlined the main tendencies prevailing in building industrialization and mechanization, it may be added that mutual interrelation exists between the improvement attained in mechanical vertical transportation equipment and the development witnessed in the use of prefabricated elements. The existing tendency to achieve an economic utilization of such equipment results in a greater degree of adaptability among contractors concerning the use of prefabricated elements. Thus, at the present moment, there exists higher probability that the use of prefabricated elements of all kinds will attain considerable proportions with the near future. In particular, the following developments are likely to materialize: a) increased use of prefabricated floors of pre-stressed concrete, b) the use of reinforced Ytong elements for walls, partitions, roofs and ceilings, c) production of gypsum elements for ceilings and partitions. In each of these fields, a considerable improvement has been recently witnessed, it is to be hoped that the manufacturing plants will shortly attain regular production.

In the future stages of development in the country's building methods, an important role will be played by the activities of building research, which has already proved its vital integrity as one of the main factors in the drive towards the improvement of existing building methods and the development of new methods.

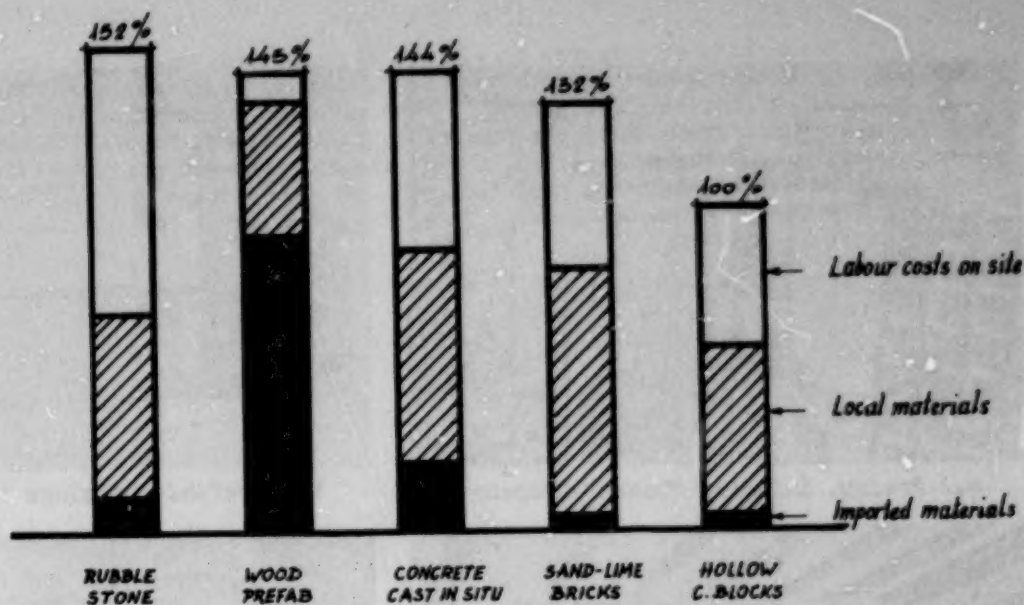


Fig. 1 : Comparison of costs per sq.m. between various wall construction systems.

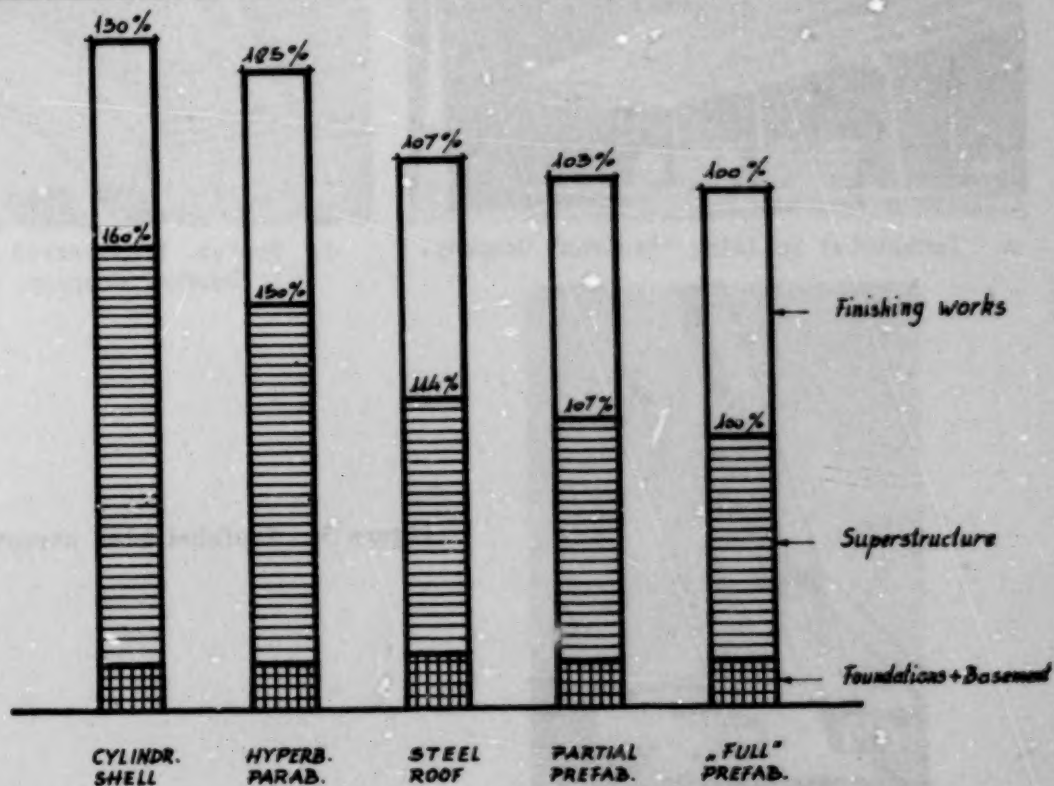
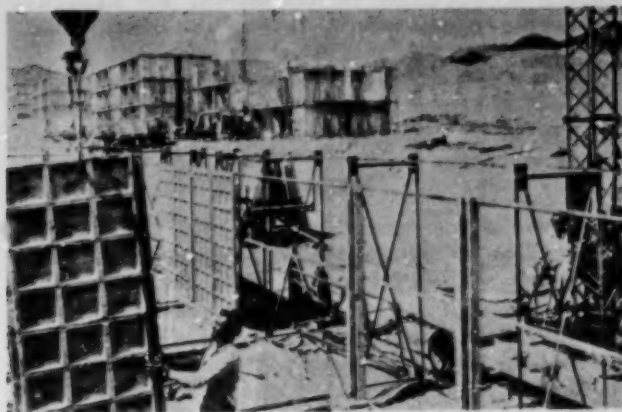
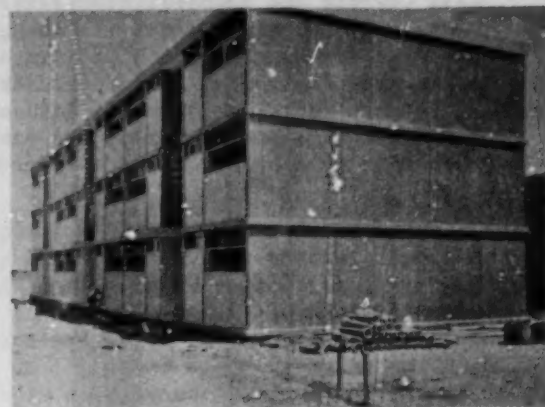


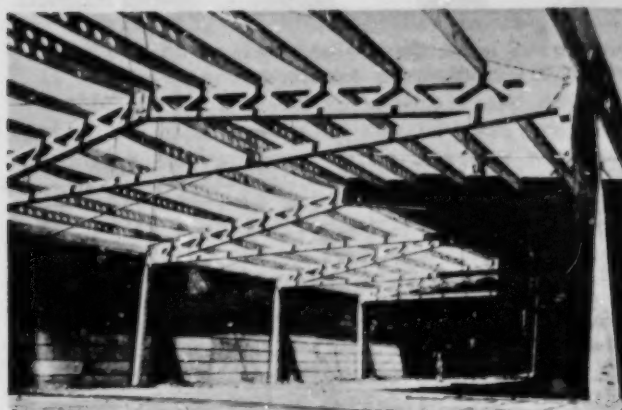
Fig. 2 : Comparison of costs per sq.m. between various systems of industrial buildings construction.



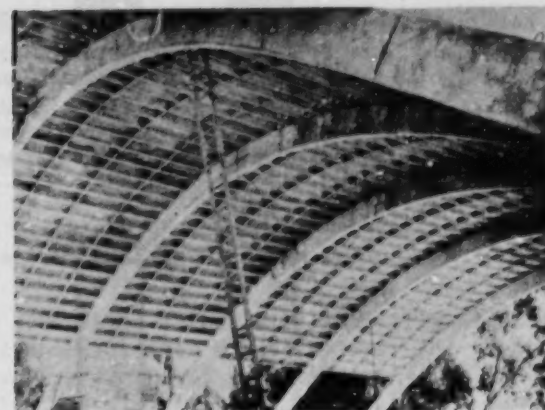
a. Prefab. Building "Mabat" Company.



b. Prefab. Buildings in Elath.



c. Industrial Building "Rastrum" Company.



d. Prefab. Prestressed Structure
"Rasrum" Company.



e. The "Diskin" System.

Figure 3. Prefabricated structures

